IS 12359 (1988): Guide for selection of wheels and castors
[MED 7: Material Handling Systems and Equipment]

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(Reaffirmed 2001)

*Indian Standard*

# GUIDE FOR SELECTION OF WHEELS AND CASTORS

Non-Powered Materials Handling Equipment Sectional Committee, MCPD 20; Castors, Wheels and Tyres Subcommittee, MCPD 20 : 2 [ Ref : Doc : MCPD 20 (548) ]

**1. Scope** — Covers the guidelines for selecting wheels and castors for manufacturing material handling equipment.

**2. Terminology** — For the purpose of this standard, the terms and definitions given in IS : 6839 ( Part 1 )-1973 'Glossary of terms relating to non-powered materials handling equipment: Part 1 Castors and wheels', shall apply.

**3. General** — Industrial castors, with load capacities of 1·35 kN to 9 kN, are of heavier construction with larger bearings, provisions for lubrication, and a wider variety of wheel and tread materials. These castors are designed for continuous service over floors that may be rough or uneven, with construction that withstands shock and bearings that minimize rolling effort. They also include types designed specifically for industrial hand trucks.

**4. Factors for Selecting Wheels and Castors** — The following factors are involved in selecting wheels and castors:

a) Load on the castor, including shock;

b) Wheel material;

c) Type of floor surface expected;

d) Effort required to start and move the product;

e) Slope up ramps or over obstructions;

f) Space available, method of mounting, location of pushing surface and rigidity of frame;

g) Environment temperature, water, oil, chemicals;

h) Maintenance lubrication, replacement of worn treads; and

j) Cost, including installation.

**4.1** *Load*

**4.1.1** There are many implications of wheel loading. Wheels shall be able to support the maximum anticipated load and are generally rated on the basis of load with a reasonable factor of safety added for contingencies.

**4.1.2** A compromise between life and cost is important in selecting the category for industiial castors. Overdesign can be expensive and underdesign may result in annoyed customers.

**4.1.3** Medium-heavy duty castors anticipate continuous operation at 4 to 5 km/h in industrial, manufacturing, and warehouse service. Tread width for these castors is 50 mm and construction is heavier; load capacity is correspondingly increased.

**4.1.4** Heavy duty castors are designed for power-drawn operation up to 6 km/h under adverse conditions for long periods of time. Tread width for these castors is 63 mm and construction is substantially heavier and load capacity higher than for medium-heavy duty.

**4.1.5** Nominal load capacities as given in IS : 7369-1983 'Specification for wheels and castors ( *first revision* )' are for actual total operational load carried on any one castor ( weight distribution on the castors under a product may not be uniform ). Furthermore rough or uneven floors, ramps and obstructions will add to the castor load. Therefore, if service conditions are expected to be severe, a higher value shall be used.

**4.1.6** After selecting the category and value for operational load per castor, the wheel diameter and tread material shall be considered. Larger diameter wheels cost somewhat more but offer lower starting resistance and are more easily manoeuvered. Softer tread materials require a lower load rating for the same wheel dimensions since materials have lower strength, and increased area of contact with the floor increases swivel friction. Castor load shall, therefore, be reduced to avoid flat spots and to aid swivelling for softer treads.

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

**4.1.7** For the category selected, the available combinations of wheel diameter and hub length offering operational load ratings equal to or above the required value may be noted. From these combinations, consideration of floor materials and manoeuverability shall further narrow the choice.

**4.2** *Wheel Materials*

**4.2.1** Characteristics of the floor surface, such as hardness, smoothness and tendency to mark or indent are determining factors in the choice of wheel tread material. Since wheels are cheaper than floor, wear should be on the castor tread, not the floor.

**4.2.2** The tread material offering the lowest cost for the operating load and life shall be selected. Wheel materials range from steel or cast iron to plastic and soft rubber. The higher strength of steel or cast iron leads to smaller size and lower cost castors for a given load rating.

**4.2.3** Steel or cast iron wheels have the highest strength and load carrying capacity. Forged steel construction is the strongest but high strength cast iron ( semi-steel ) is most often used for heavy duty metal wheels. Steel treads have low rolling resistance but are noisy on hard floors and transmit floor shocks. They wear rapidly on rough concrete or brick floors but are unaffected by temperature extremes.

**4.2.4** Softer tread materials ( shore hardness $< 90$ ) such as canvas-filled phenolic or moulded hard rubber ( shore hardness $> 90$ ) are easier on the floor, quieter than steel and more resistant to shock. Moulded phenolic treads are more subject to wear than steel under good floor conditions but are not attacked by moisture or chemicals. However, these tread materials are not suitable for rough floors, for contact with strong acids or alkalis, or for service temperatures above 121°C. Unless a water resistant compound is specified, phenolic wheels tend to get mushy in water.

**4.2.5** Soft rubber treads are supplied on hard rubber or metal wheels to provide the best protection for finished floors. They are quiet, absorb shock and vibration and reduce rolling resistance over uneven floors or litter. Load ratings, however, are substantially less than that for phenolic or steel treads.

**4.2.6** Rubber is attacked by oil and grease and softens with heat. Carbon black in the rubber tends to stain or mark vinyl or linoleum floors unless non-marking, stain-resistant rubber is specified. Under extended time at rest, compression set may flatten soft rubber treads on poor quality wheels; even moderately elevated temperatures will increase this tendency to set. Maximum service temperature is 65°C unless a heat-resistant material is used.

**4.2.7** Although material cost of polyurethane tread bonded to a steel wheel is higher than that for rubber or phenolic, this tread combines the higher strength and wear resistance of phenolic or hard rubber with the resilience of soft rubber. Load ratings are comparable to or higher than the standard values for steel tread wheels of the same diameter and width.

**4.2.8** Polyurethane treads do not mark plastic floors and resist wear from dirt, litter, or rough floors. Reduced tendency to flatten under load cuts down rolling resistance and swivel friction. Cost premium is reduced by the opportunity to use a smaller wheel diameter of the same load rating. For example, a 75 mm wheel with a polyurethane tread has a load rating higher than that of 200 mm wheel of the same width with a soft-rubber tread.

**4.3** *Effect of Floors*

**4.3.1** Wood block or plank floors can withstand wear from steel or cast iron wheels if load ratings as given in IS : 7369-1983 are followed in selecting wheel diameter and hub length but unit pressures in this range are too high for steel wheels on finished hardwood floors; therefore, a softer wheel material, such as moulded plastic or hard rubber may be required to avoid damage.

**4.3.2** Concrete, asphalt, or terrazzo surfaces also call for a wheel material softer than steel to protect the floor from damage. But high unit pressure transmitted by hard concrete floors may damage hard rubber or moulded plastic wheels under shock loads met in uneven floor surfaces or in running over litter on the floor. Under these conditions, wheels with soft-rubber or polyurethane treads will stand up better while avoiding floor damage but a larger wheel diameter is needed to handle the same load without flattening the wheel tread and increasing the resistance to swivelling.

**4.3.3** Linoleum or plastic tile floors require a wheel material softer than the floor with a contact area large enough to avoid indentation when standing for extended time. Unit pressures can be reduced by selecting a heavier duty wheel with wider tread but this increases the swivel friction and cost. Therefore, it is advisable to go in for a lighter duty, larger wheel with a higher load rating.

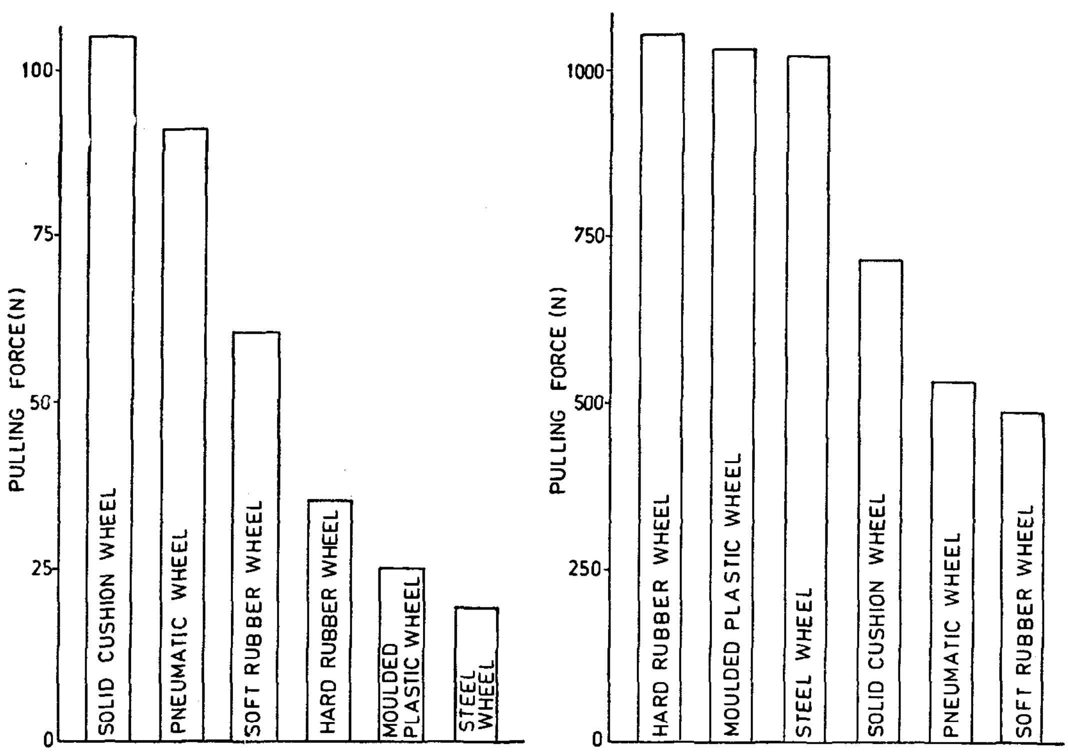
**4.3.4** Some light-colour plastic floors are marked by plastic or rubber treads. Marking may arise from rolling contact between tread and floor, or may show up only after the castor stands for extended time. Where these conditions are anticipated, a non-marking tread material shall be specified. The new polyurethane treads are non-staining but are not yet available on smaller size wheels.

**4.4** *Effort Required to Start and Move the Product*

**4.4.1** Pushing is easier than pulling. For a standing operator, the height of the pushed surface shall be 750 to 1 000 mm above the floor. Maximum pushing force, including rolling resistance, vertical components of weight on a ramp, and lifting force over an obstacle is 225 N for intermittent movement. For extensive movement or repeated movement over short distances, a force of 158 to 180 N is about the highest that can be expected. Where products are frequently moved or positioned for convenience by a seated operator, total resistance shall be kept under 68 or 90 N.

**4.4.2** Resistance to rolling offered by a castor on a smooth surface depends on bearing friction and on flattening of the tread and yielding of the floor under load. A steel or cast-iron wheel offers the lowest starting resistance; moulded plastic, rubber, and semi-pneumatic tyres have greater resistance, as shown in Fig. 1.

**4.4.3** Deformation of softer wheel materials increases rolling resistance because the castor wheel has to continuously climb up the ramp produced by its deflection. But with larger wheels, deformation is less and the rolling resistance is reduced, as shown in Fig. 2 and 3.



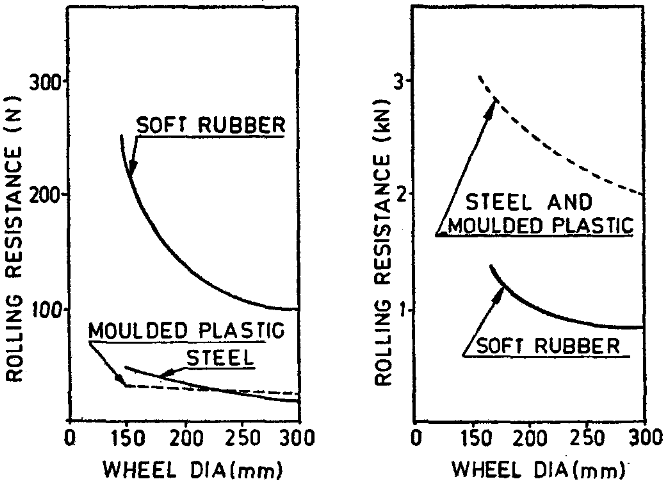

1A Smooth Floor

1B Rough Floor

FIG. 1 STARTING ROLLING RESISTANCE AS EFFECTED BY TREAD MATERIAL FOR 155 mm $\phi$ ROLLER BEARING WHEELS WITH 2·70 kN LOAD

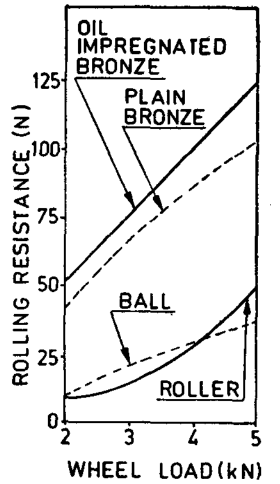
**4.4.4** When a small obstacle ( 3 mm ) is met by a hard wheel on the floor, the rolling resistance is increased by the work required to lift the castor load over the obstacle. A softer wheel in meeting the same obstacle will deform and decrease the lifting load ( *see* Fig. 1B ). Where litter or floor roughness is expected, a large wheel of softer material may offer lower average rolling resistance than a steel or cast iron wheel. The advantage of the softer wheel is increased substantially when considering the effort required to start rolling with the wheel against a floor obstruction.

**4.4.5** Floor roughness also has a large influence on rolling resistance. Values depend on a number of related factors such as wheel diameter and tread material but Table 1 offers a general guide for moulded rubber treads on typical surfaces.




2A Smooth Floor 2B Rough Floor

FIG. 2 ROLLING RESISTANCE WITH 2·7 kN LOAD ON THE WHEELS




Smooth Floor

FIG. 3 ROLLING RESISTANCE WITH 150 mm $\phi$ WHEEL

**TABLE 1 AVERAGE ROLLING RESISTANCE FOR SOFT RUBBER TYRES**

( *Clause* 4.4.5 )

| Floor Surface | Percent of Load |
|---|---|
| Concrete | 1·0 to 2·0 |
| Asphalt | 1·0 to 2·5 |
| Wood block | 1·5 to 2·5 |
| Loose sand | 1·5 to 3·0 |
| Stone | 1·5 to 3·5 |
| Pneumatic tyre on smooth pavement | 0·2 to 3·0 |

**4.4.6** Bearing friction also affects starting resistance. When castor loads are high, ball or roller bearings can reduce starting force to less than half the amount required for sleeve bearings as shown in Fig. 2 and 3 above.

**4.4.7** Where the product is rolled up a ramp or grade, additional force is required to lift the load. With good floor conditions and wheels with low rolling friction, the maximum load an operator can push up a 5° ramp is 1·8 kN to 2·25 kN. Special attention shall be given to minimize rolling friction. This includes wheels of larger diameter, treads with less deflection and lubricated ball or roller wheel bearings.

**4.4.8** In case of product rolling over door jambs, on to elevator platforms or over obstacles on the floor, such as cables, some additional force is required. For a given obstacle height, climbing effort decreases with wheel diameter but space requirements go up as swivel radius and mounting plate dimensions increase. The compromise, then, shall be between increased wheel diameter for easy operation and increased castor height and cost.

**4.5** *Bearings*

**4.5.1** Commercial roller bearings incorporate a split outer race of hardened steel with hardened rollers bearing on a hardened axle. Lubrication shall be provided by a pressure grease fitting on the axle bolt or on the wheel hub. Side thrust is taken between wheel hub and castor horn.

**4.5.2** Where loads are high, tapered roller bearings have low starting and rolling friction. They match the load capacity of the wheel and tread and also take thrust loads.

**4.6** *Manoeuverability*

**4.6.1** Major factors affecting manoeuverability are the load on the castor, diameter and tread of the wheel, design of the swivel bearings, and lead or offset of the castor. Increased load on a castor increases the friction at the wheel tread and in the swivel bearing. Wider treads required for heavy loads offer increased resistance to change in direction; larger balls and larger race diameter, and provision for lubrication, reduce swivel friction. Increased load reduces swivel resistance but increases the clearance space required for the castor, and on closely spaced castors may increase the tendency to tip.

**4.6.2** When easy change in direction is essential, a castor with a narrow tread and a larger size than required for structural strength or load capacity may be needed. Heavier duty types with the same wheel diameter have larger swivel bearing races, larger balls, and larger swivel radius.

**4.6.3** Usually the swivel castor is placed at each corner of the product but other arrangements as given in Fig. 4 may increase manoeuverability. Four swivel castors permit movement in any direction as well as right-angle changes in direction that are helpful in moving equipment into a tight spot (*see* Fig. 4A). But if the product is moved a considerable distance, steering is much easier with two fixed castors at the front and two swivel castors at the rear (*see* Fig. 4D). Three swivel castors maintain contact on uneven floors but present tipping problem at floor obstacles (*see* Fig. 4B) while two rigid and two swivel castors in a diamond pattern offer good manoeuverability in confined areas (*see* Fig. 4C).

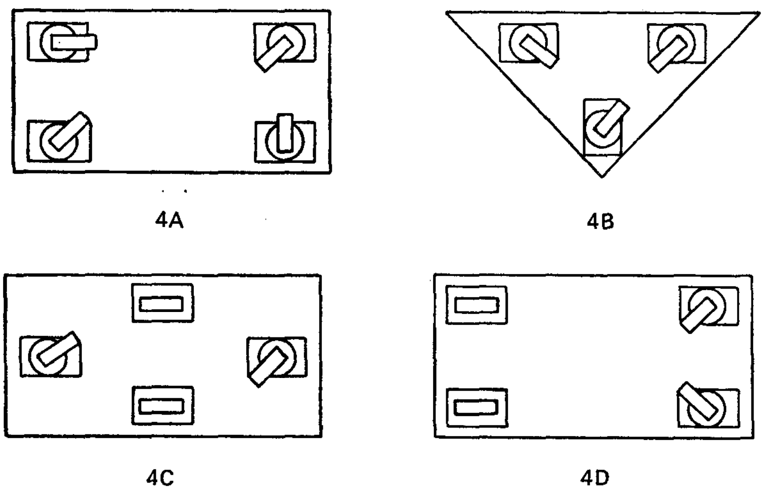


FIG. 4 CASTER ARRANGEMENTS

**4.6.4** All manufacturers produce rigid plate castors matching swivel types in wheel dimensions, overall height, and mounting dimensions. Some manufacturers supply a swivel castor that can be locked in position, usually at 90° and thus convert a swivel to a fixed castor when needed for easier steering.

**4.7** *Space Requirement*

**4.7.1** Castors take space, and when the space is allowed for early in the design, standard castors can save money. Maximum overall height and mounting plate dimensions are standardized for castors of a given wheel diameter and tread width. IS : 7261-1985 'Dimensions of top-plates for castors' provides mounting plate dimensions for a complete range of sizes of industrial castors.

**4.7.2** Special castors can be supplied with special mountings, reduced height, or smaller swivel radius when space limitations justify the added expense. Any deviation from established standards can be expected to increase the cost and delay delivery.

**4.8** *Environment*

**4.8.1** When service conditions are likely to include exposure to oil, grease, water, chemicals, elevated temperatures, or extreme cold, problems arise in lubrication and in the selection of tread material.

**4.8.2** Cast iron and steel wheels rust; moulded plastic wheels and treads withstand moisture and are unaffected by common oils and greases, cleaning compounds, alcohol, most organic acids, and some concentrated alkaline solutions. Maximun service temperature is about 121°C.

**4.8.3** Rubber wheels and treads are damaged by oils, greases, and gasoline. Where the resilience of rubber is needed under these conditions, some types can be supplied with neoprene treads. Rubber treads develop flat spots on standing and moderately elevated temperatures increase the tendency. Maximum service temperature for rubber tread is 65°C.

**4.8.4** Exposure to weather, moisture, or elevated temperature may introduce problems in bearing life. In light to medium duty castors, swivel bearings are not sealed, and splashing water can carry dirt into the bearings. Some heavy duty types are supplied with seals to protect swivel bearings and retain lubricant but seals increase swivel friction.

**4.8.5** Low temperatures can also be a problem with rubber wheels. For continuous operation at sub-zero temperatures, moulded plastic wheels are little affected even at −40°C.

**4.8.6** All steel wheels create noise particularly on rough floors. Rubber or plastic treads will reduce noise, at some increase in wear on hard floors or where litter is present. Under these conditions, polyurethane treads are quiet and wear resistant.

**4.8.7** Heavy duty castors with tapered roller bearings are supplied with seals that retain lubricant and exclude dirt and moisture.

## 5. Accessories

**5.1** Larger sizes of industrial castors are available with foot-operated wheel brakes that lock the wheel to the horn. The braking action may be applied to the hub or the tread.

**5.2** Where the product needs extra protection from shock in moving over obstruction or uneven floors, spring supported castors are used. Selection of size depends more on speed of travel and floor conditions; than on load conditions the manufacturer may be asked for recommendations.

**5.3** Semi-pneumatic rubber tyres in diameters of 100 mm and larger are used where added flexibility or floor protection is needed. Load capacities are limited by rolling resistance, and are much lower than for solid wheels of the same diameter. Various cross sections are offered, from thin wall to solid core, the load capacity increasing with wall thickness. Operating speed is limited to 3 to 6 km/h because of internal heating.

**5.4** Where floors are littered, saucer type castors swivel easier, cost less, and take less height than a standard castor. For the space they require, these castors last longer and stand up better under impact but loads shall be kept under 1·12 kN to avoid damage to floors. They are more likely to stick in cracks such as at elevator doors but they will not clog with string.

**5.5** Special grease seals can be supplied for swivel and wheel bearings when castors are subject to hot water or steam cleaning. Also, special sanitary grease seals are available meeting food service and bakery specifications. Stainless steel and aluminium can be specified for structural parts for corrosion resistance. When good appearance is essential, a multiple-coat enamel or lacquer finish is obtainable. These special features add to the cost.

## EXPLANATORY NOTE

For different types of material handling equipment, there are different types of wheels and castors. The manufacturers of these equipments use wheels and castors depending on the mode of use of those equipments. In fact, wheels and castors play an important role as far as transportation of loads by those equipments are concerned. Selection of castors involves the choices : types of swivel bearing, depending on duty; bearing for wheel, depending on rolling resistance; and type of wheel and tread, depending on floor conditions. This standard has been developed to facilitate the manufacturers of material handling equipment in selecting the right type and size of wheels and castors.

Assistance may also be derived from IS : 7369-1983 'Specifications for wheels and castors ( *first revision* )' in selecting the category when the operational load and wheel sizes are known.



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